

Status of the Light Dark Matter KAW Project

Partikeldagarna 2021

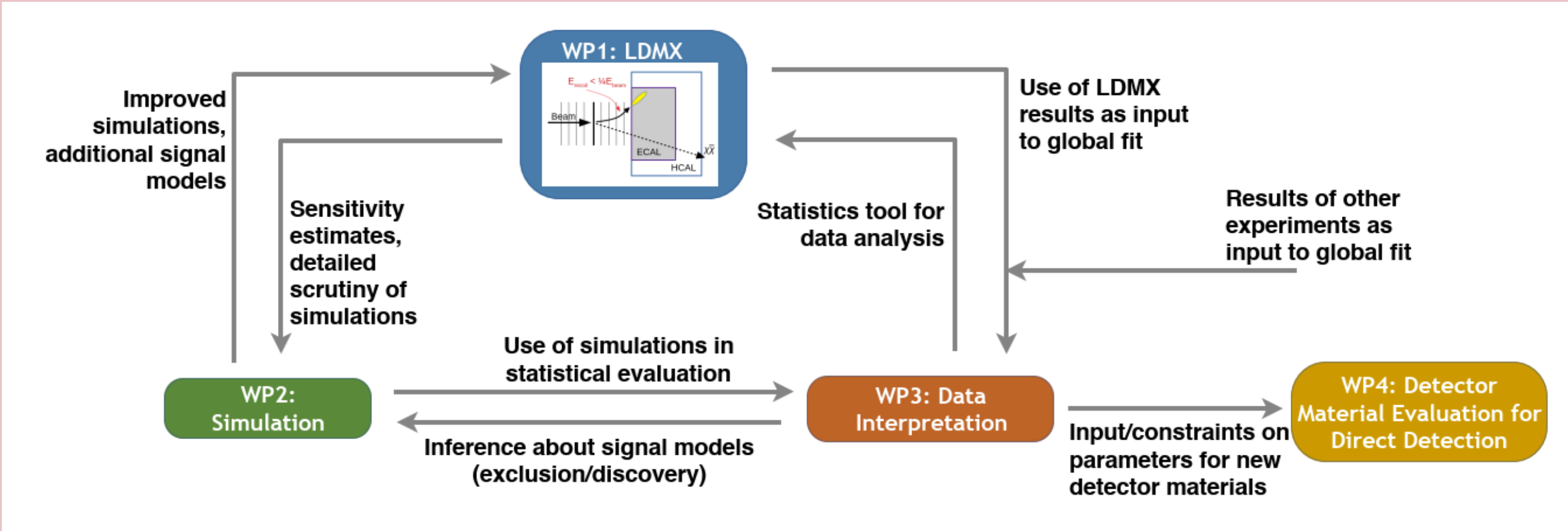
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About the project

- Project aiming at lasting impact on wider Swedish DM landscape, with LDMX participation as major component
- Split into four parts (Work packages)
 - WP1: The Light Dark Matter eXperiment (LDMX)
 - WP2: Simulation
 - WP3: Statistical inference package to LDMX and global data interpretation
 - WP4: Detector material evaluation for direct detection
- Today, nothing about LDMX
 - See talks by Ruth Pöttgen, Erik Wallin, and Péter György

Overview




Simulation

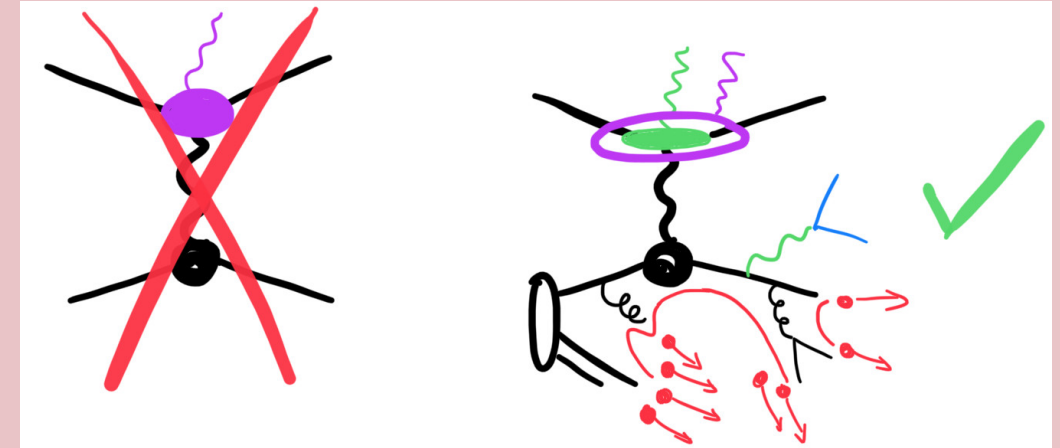
- Wide range of activities
 - BSM modelling to detector simulation
 - New tools, improvements, and validation
- Zero background
 - Requires detailed simulation
 - Careful handling of rare background events
- BSM modelling, Pythia8, Geant4

Additional models and phenomenology at LDMX

- Current analysis focuses on spin 0 and 1/2 dark matter
- Broaden range of models explored at LDMX
- Increased generality + potential to extract spin information
 - Spin 1 models
- Simple dark photon models do not provide a mechanism for giving the dark photon mass
 - Additional higgs field responsible for dark matter mass
- Requires studying phenomenology at LDMX

Pythia8 development

- Flexible signal simulation using full matrix elements
 - Including all quantum interferences
 - BSM model can be replaced by linking another dynamic matrix element library
 - Implementation is *not* LDMX-specific
- Current status:
 - Works for two models
 - Ongoing work with algorithmic issues very close to the dark photon resonance mass
 - Code is available and open-source at gitlab.com/dire/direforpythia 
 - As well as container + tutorial
- Future:
 - Make model switching trivial
 - Add models from previous section + LHC

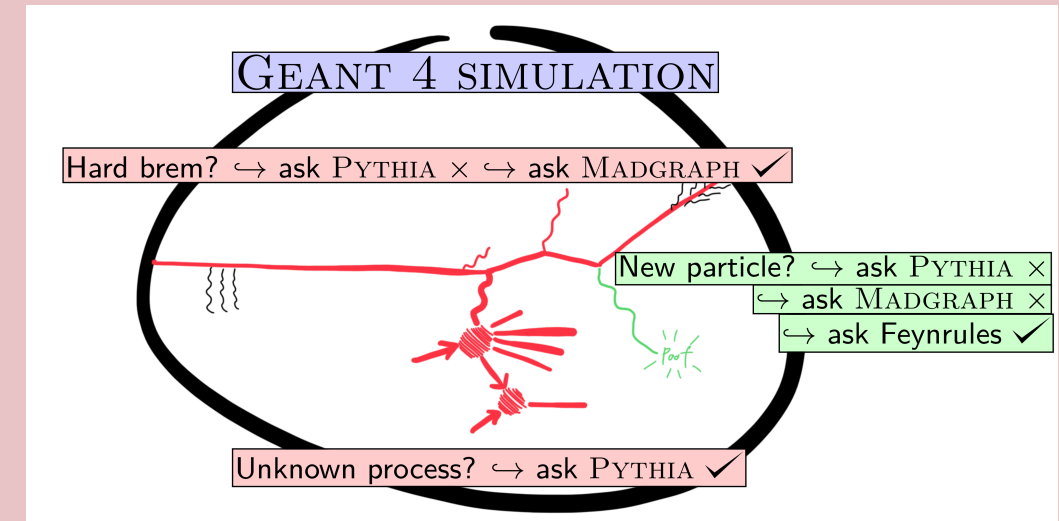


Geant4 validation with FLUKA/MCNP/PHITS

- Neutral hadron rejection is crucial
- Geant4 modelling of detector response to neutrons drives hadronic calorimeter design
- Need to ensure the quality of the Geant4 results
 - Compare with FLUKA, MCNP, and PHITS
 - Collaborators in LDMX are looking at differences *between* Geant4 versions

Geant4 and Pythia8 integration

- No clear separation between event generation and detector simulation
- Embed Pythia8 in Geant4
 - Replace default generation in Geant4 with Pythia8 for unknown/signal processes
 - Supplemented by MadGraph and Feynrules
 - We have an initial prototype
 - No physics list integration
- Development is done in direct connection with the Geant4 collaboration

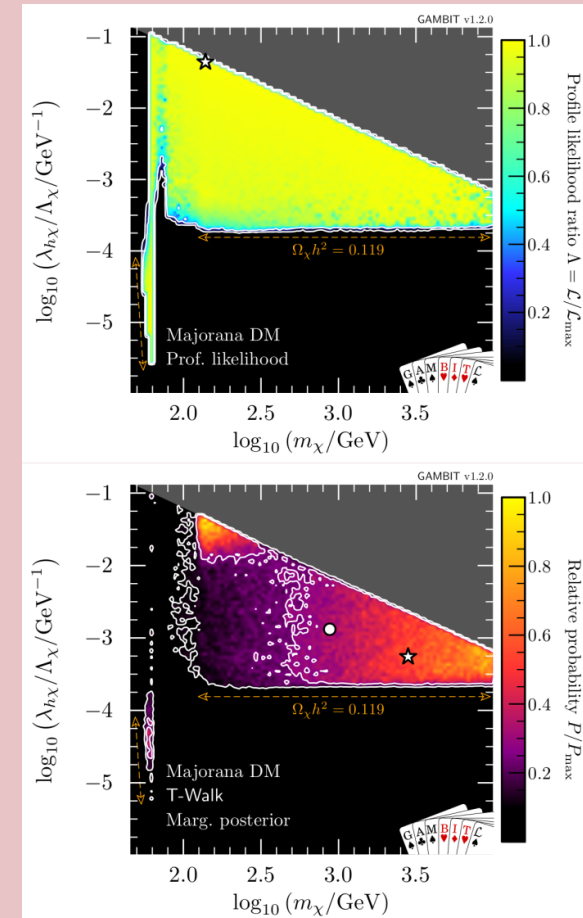


Statistical inference and global data interpretation

- Analysis requires robust statistical tools
- Joint analysis with LDMX and other DM searches
 - Allows the larger community to benefit from LDMX developments

Likelihood calculations and GAMBIT

- Different experiments will probe different regions of parameter space for different models
 - N-dimensional likelihood-based tests rather than 2D grid scans
- Requires tools for computing Dark Matter signals
- LDMX likelihood calculator to interface with Global And Modular BSM Inference Toolkit (GAMBIT)

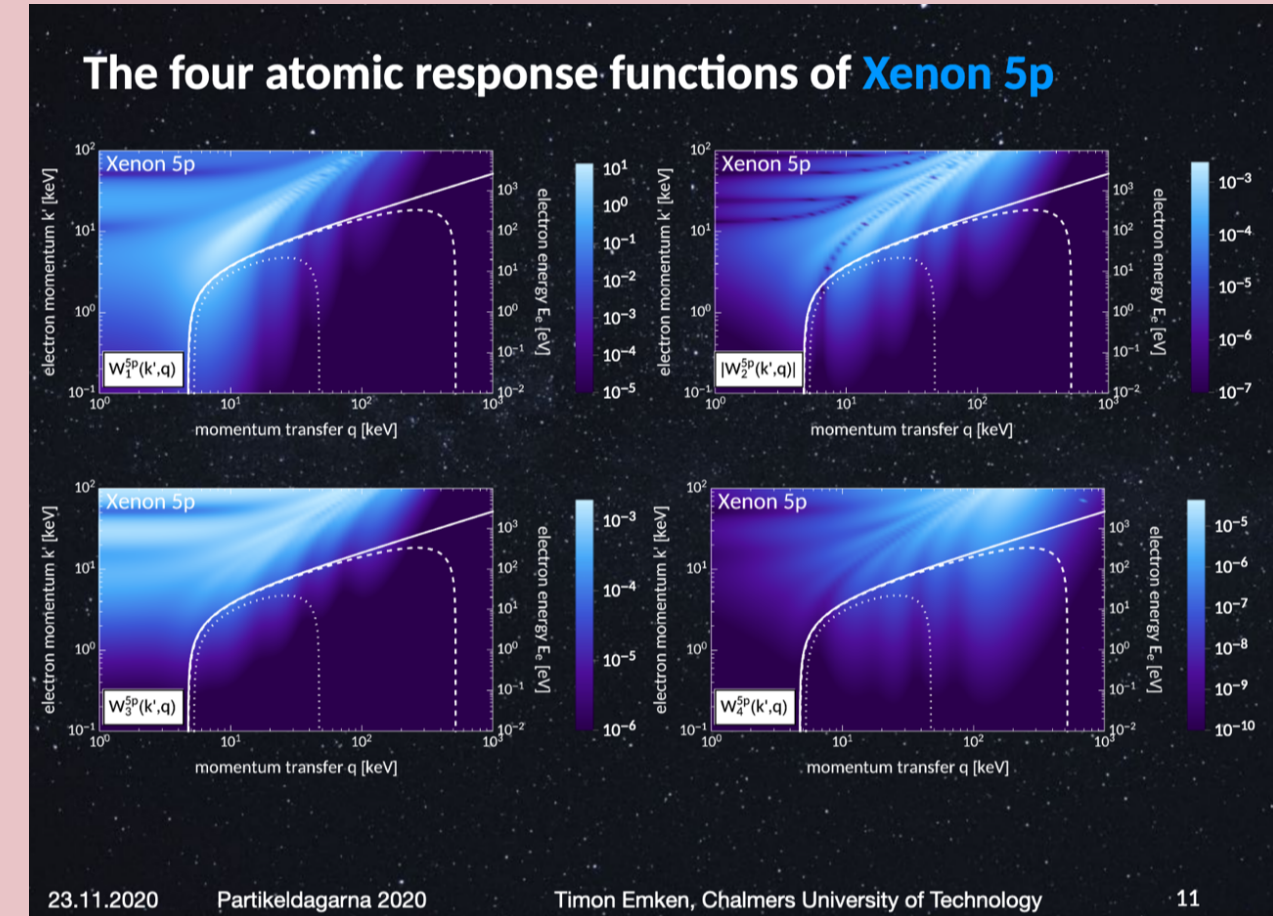


Detector material evaluation for direct detection

- DM particle origin of a hypothetical LDMX signal needs to be validated
- Validation strategies based on direct detection
 - Primarily electron recoil

Direct detection

- Original focus on atomic targets
 - Recent focus on crystals
 - In collaboration with condensed matter
- C++ library for general sub-GeV direct detection experiments
 - Interfacing with GAMBIT
 - The code is available and open-source at: <https://timonemken.com/code/>



Questions?

- About the project
- Simulation
- Statistical inference and global data interpretation
- Detector material evaluation for direct detection
- **Questions?**